

# Galactic Black Holes and Binaries in Nearby Galaxies

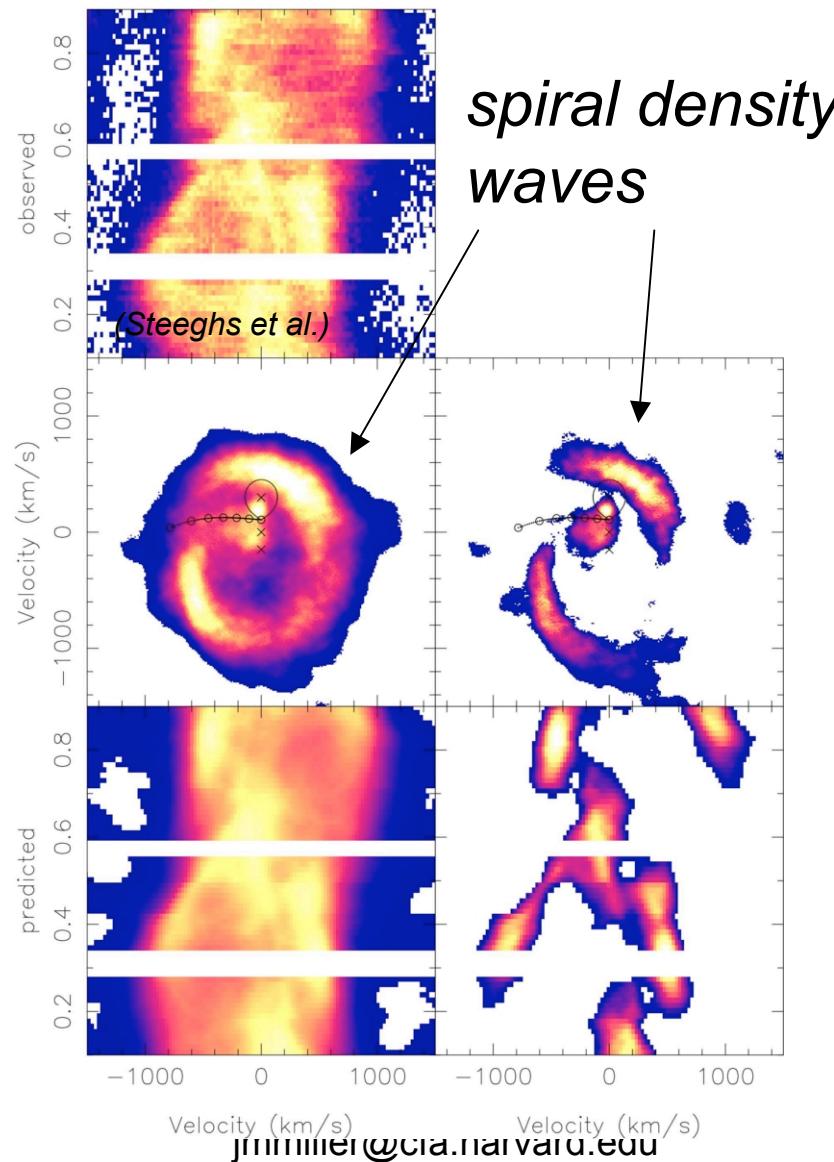
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# With Fe K lines, we see down to $<6M_{\odot}$ ... so what?

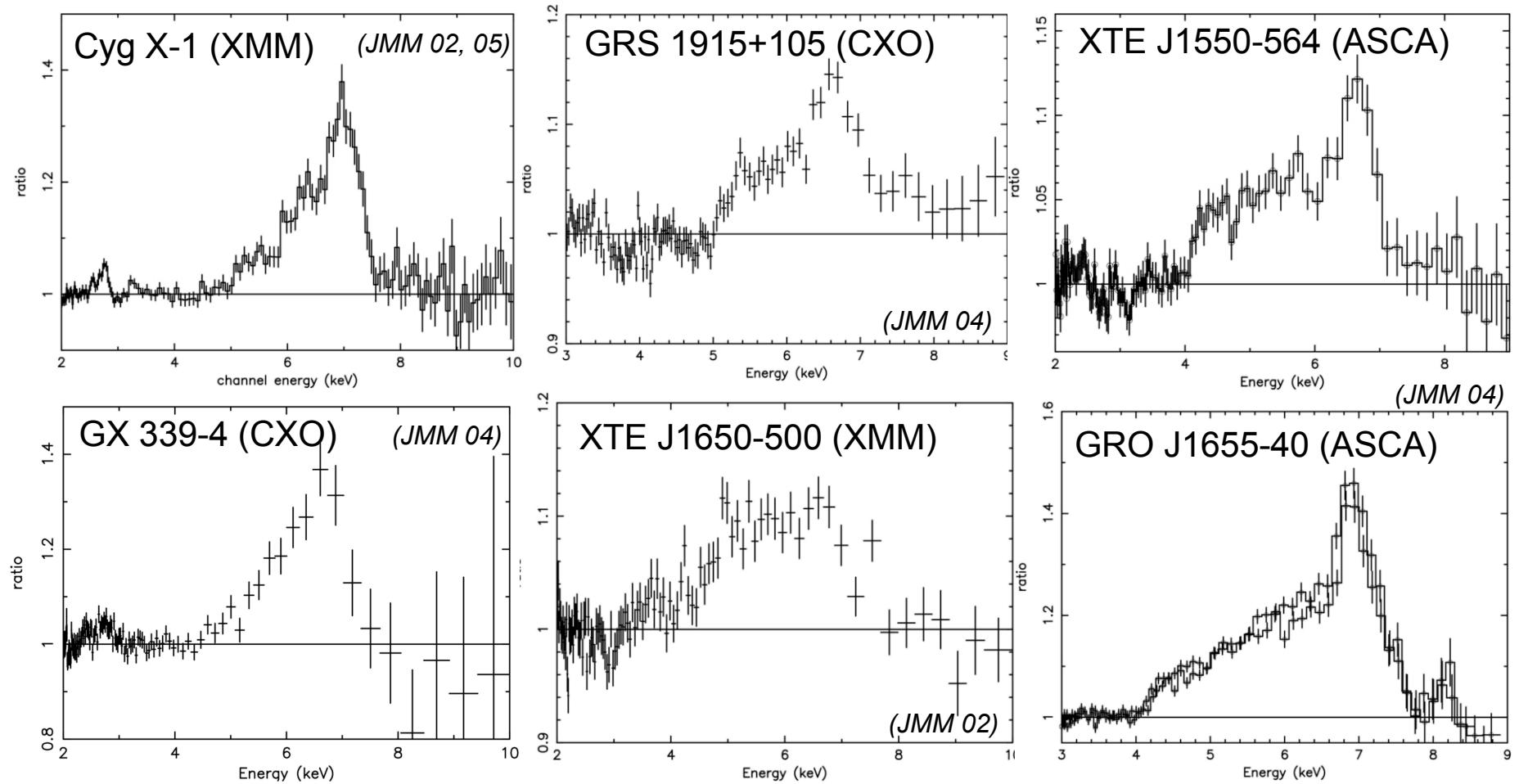
- BH spin, demographics, examine origin of spin.
  - BH and Kerr phenomena (light bending, frame dragging).
  - Origins of jets and spin-jet connections.
  - Resolve the nature of low m-dot accretion flows.
- ◊ You can do all of this across the BH mass scale.

# Big Scopes + Bright Sources = Progress

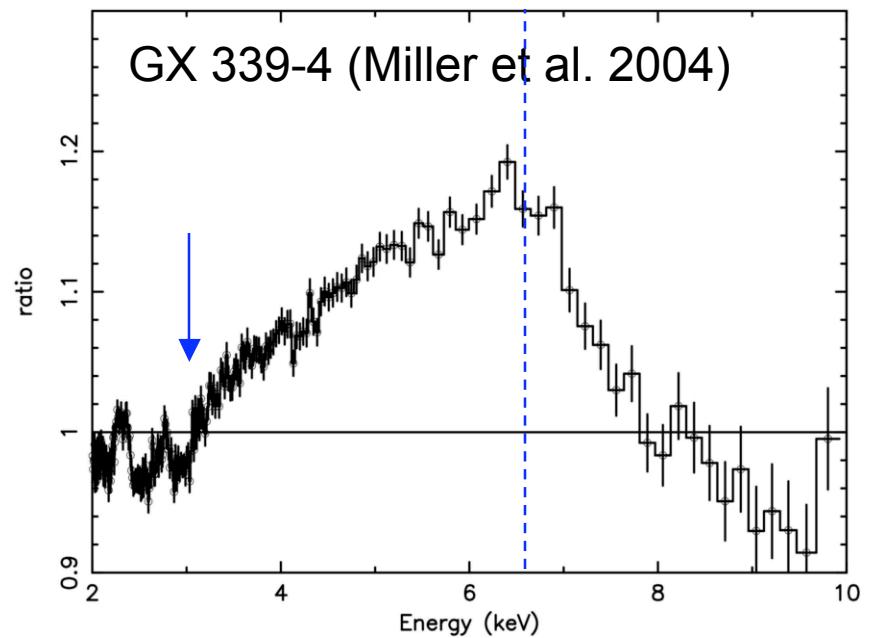
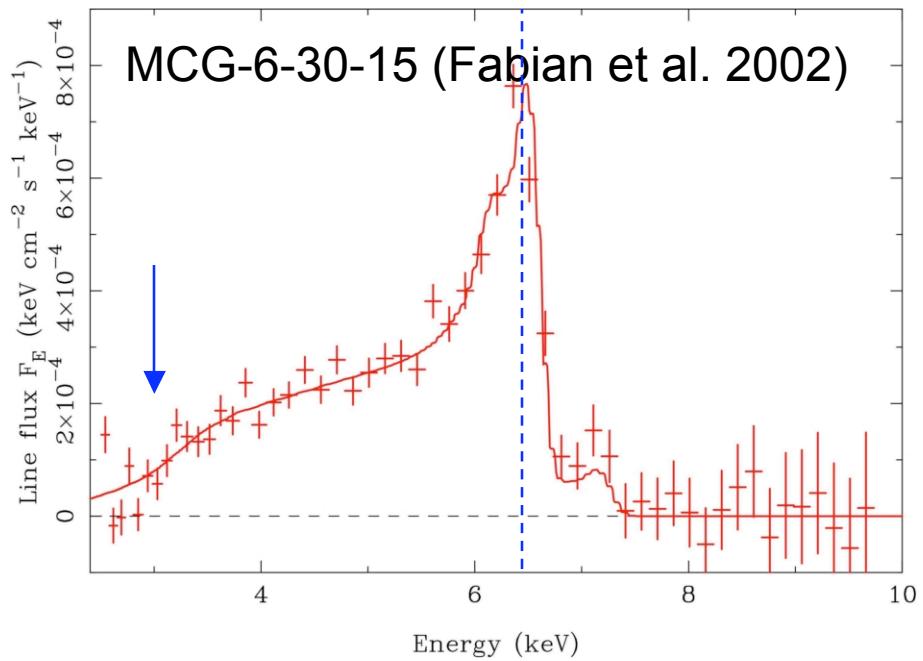
IP PEG Hell(4686)



# Relativistic Lines in Galactic BHs

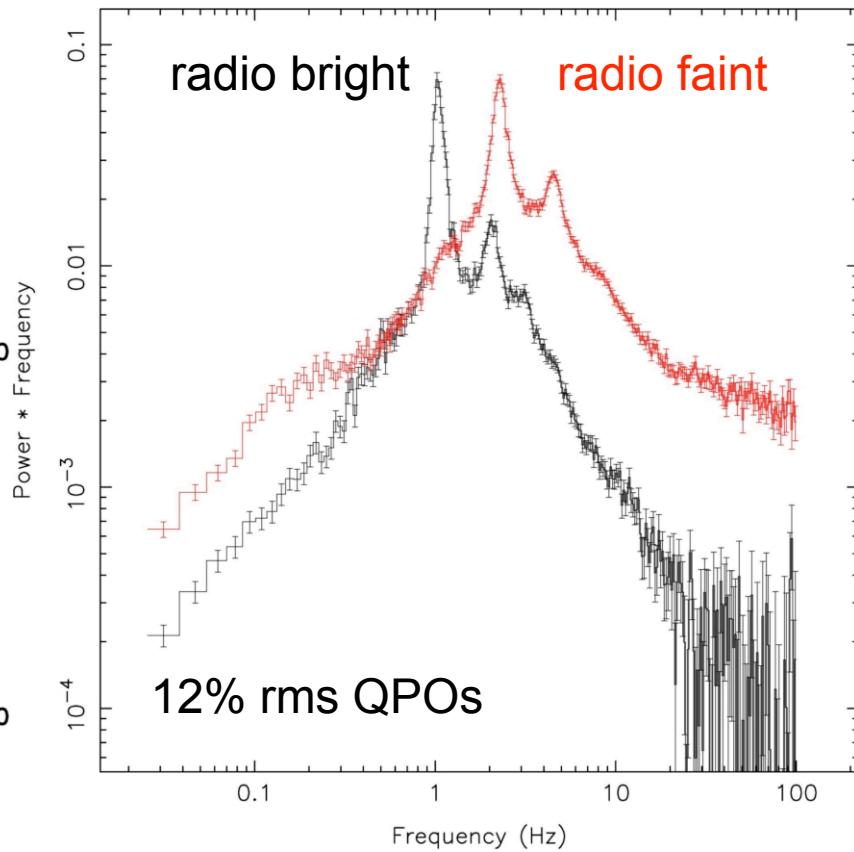
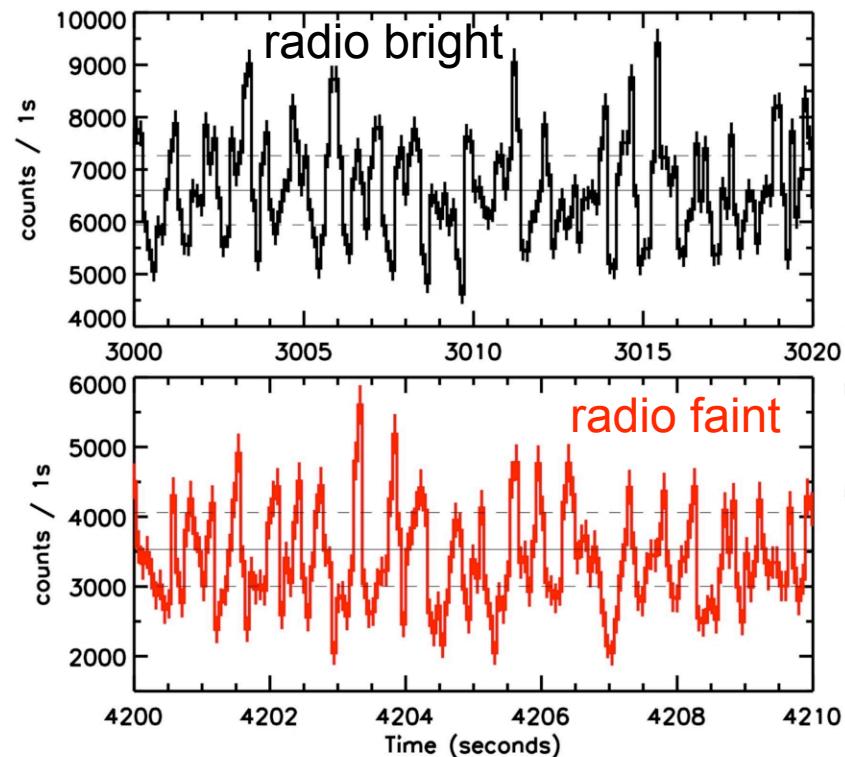


# BHC – Seyfert Connections



- Both lines require  $R_{\text{in}} \sim 2 R_g$ , high spin ( $a/M > 0.8-0.9$  or so).
- Centrally concentrated emission,  $J(r) \sim r^{-q}$ ,  $q = 4-5$  ( $q=3$  expected).
- Inner accretion flows must be *remarkably* similar.

# QPO Phase-resolved spectroscopy

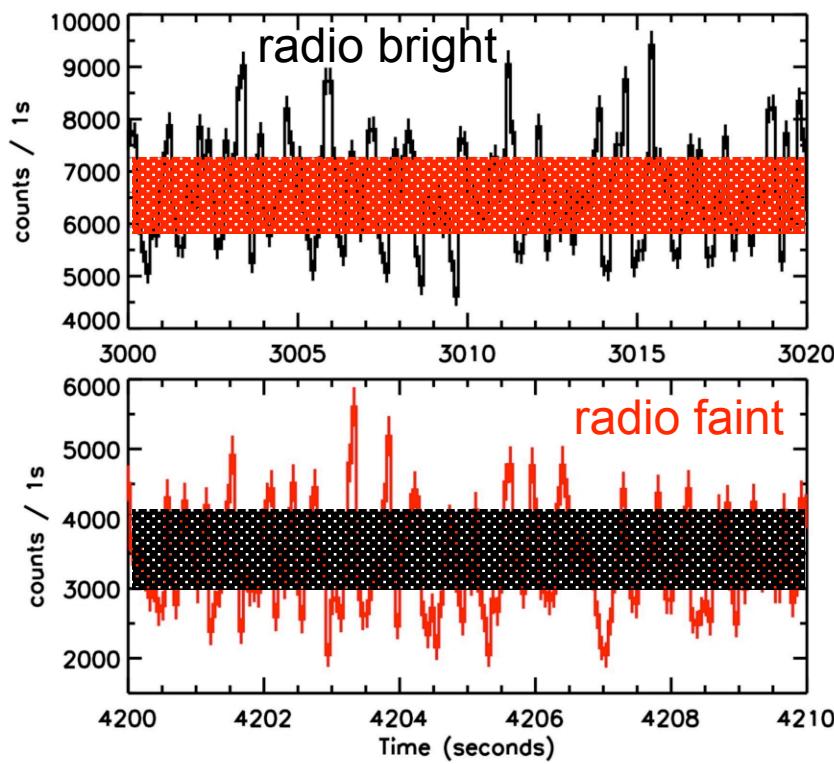


**GRS 1915+105, RXTE**

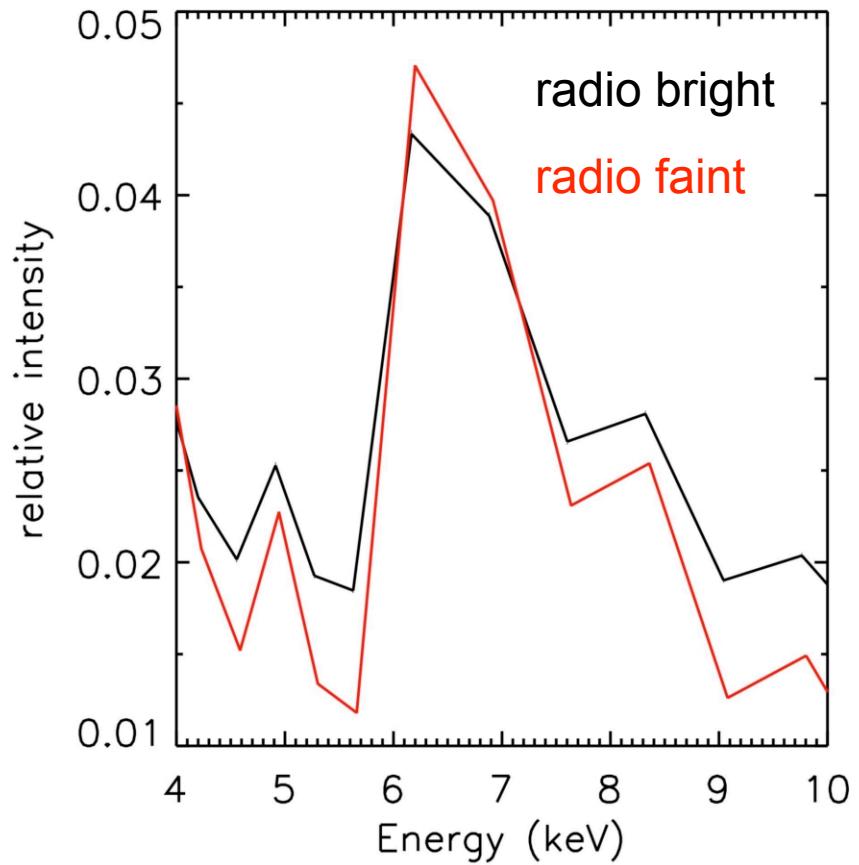
(Miller & Homan 05)

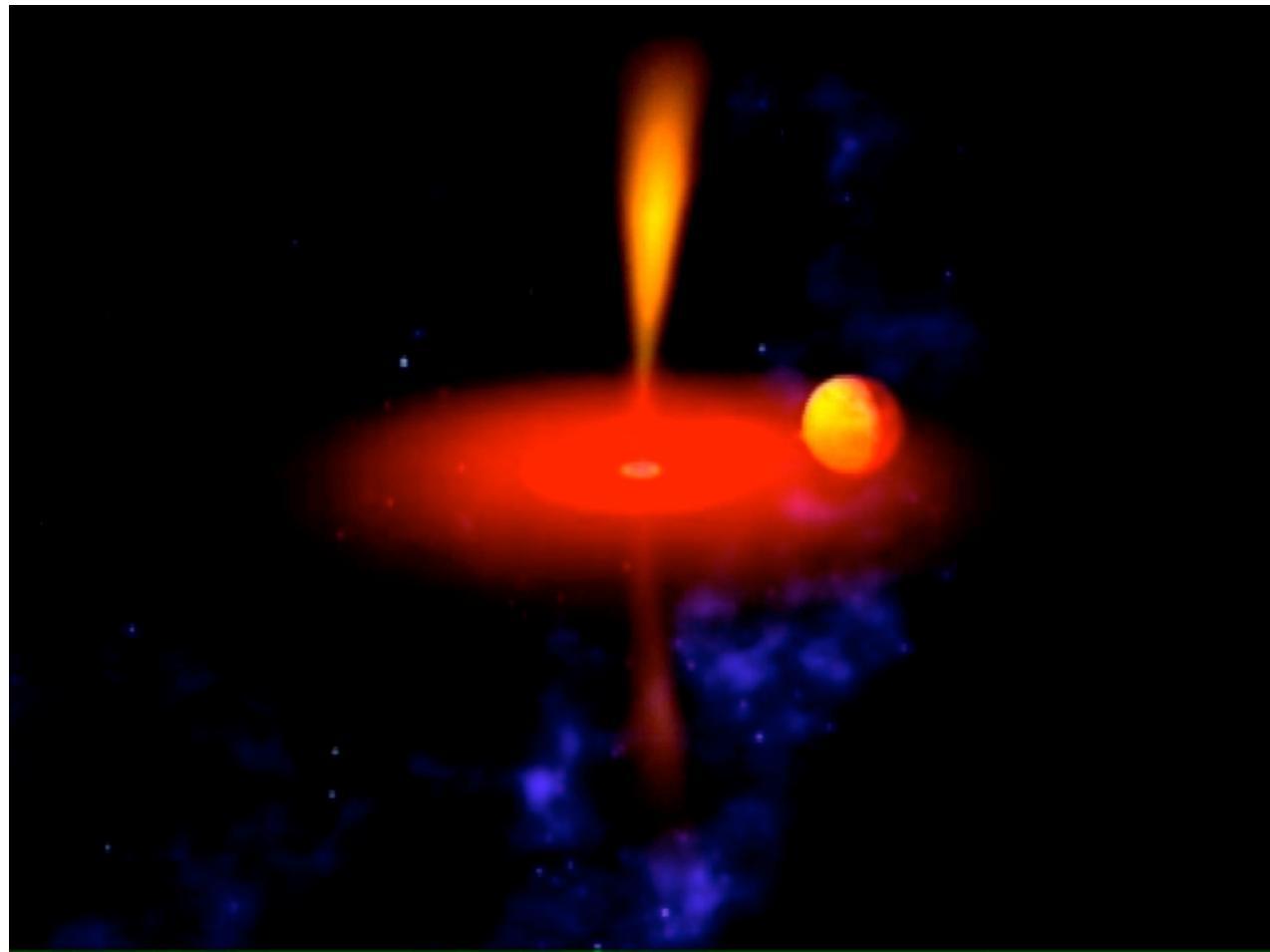
# Difference Spectra: High – Low QPO Phase

***The iron line is relatively more important at the top of the QPO than at the bottom – the line does not merely trace the overall flux.***



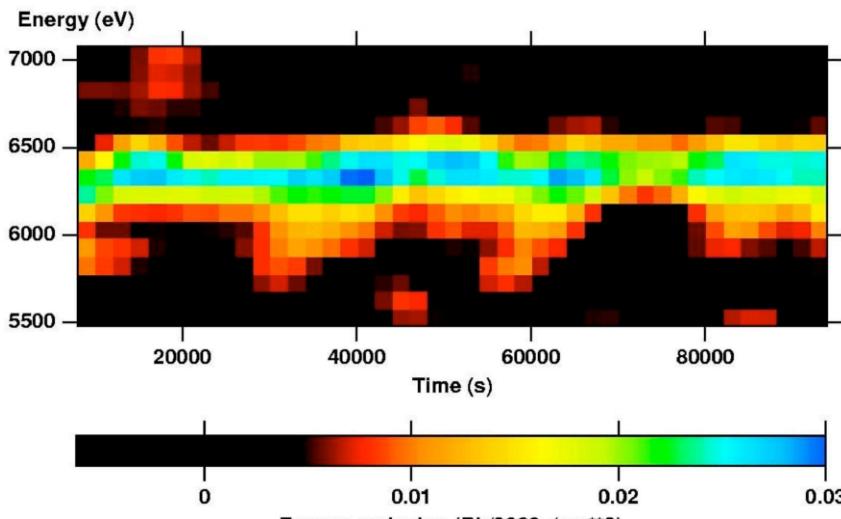
(Miller & Homan 05)



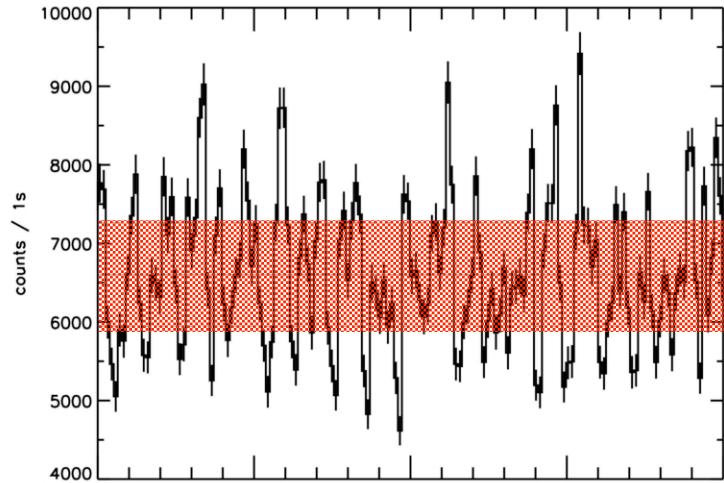


# ConXEUS will probe orbits

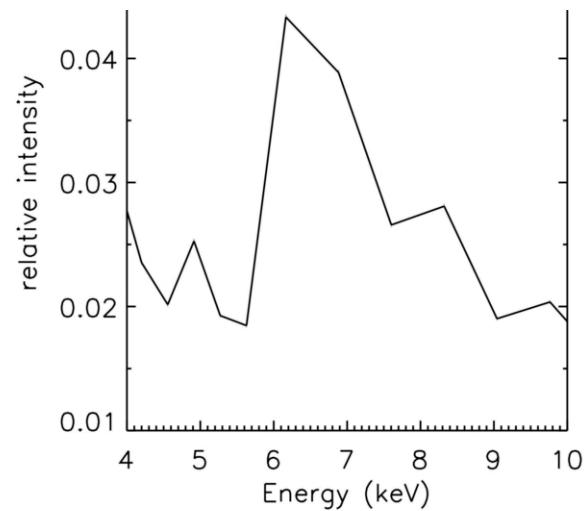
**Modulation of the Iron line flux in NGC 3516 ( $M \sim 10$  Million Msun)**



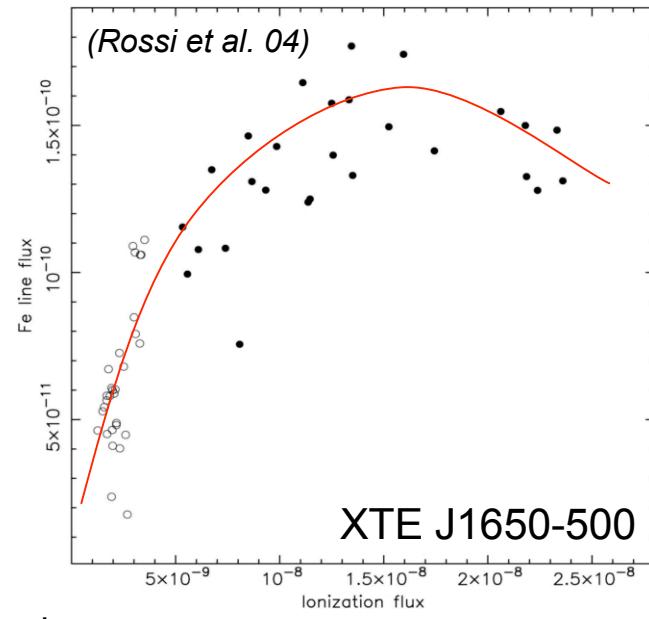
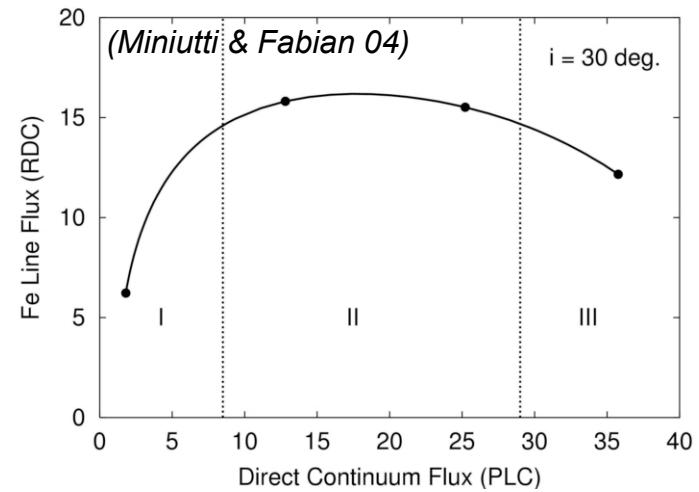
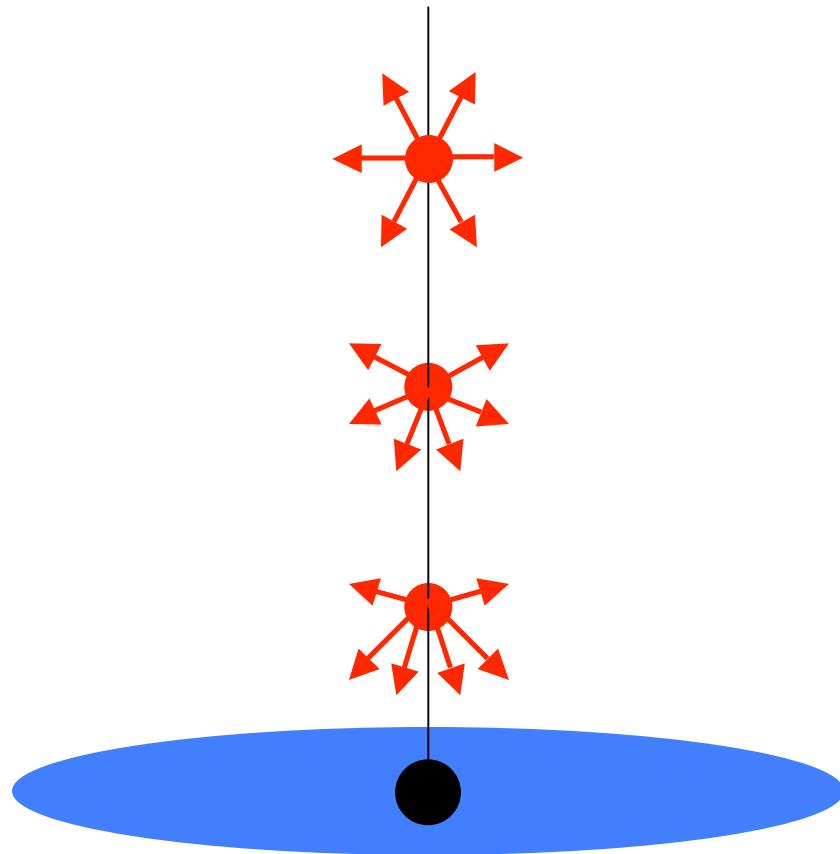
(Iwasawa, Miniutti, & Fabian 2004)



**Modulation of the Iron line flux in GRS 1915+105 ( $M = 14$  Msun)**



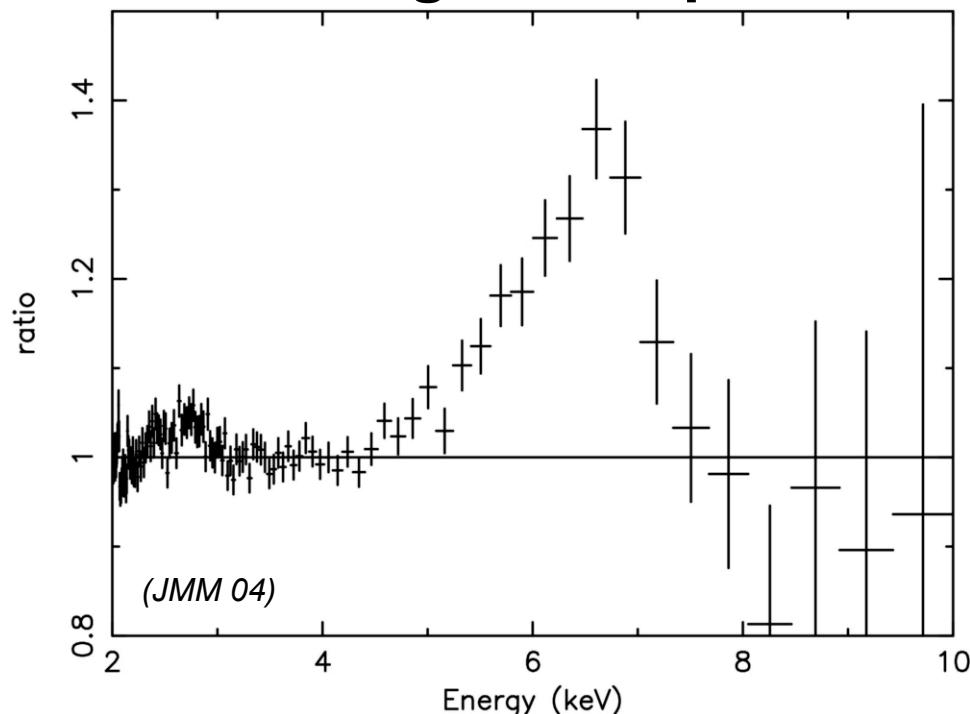
# Gravitational light bending



# Chandra/HETGS Spectra

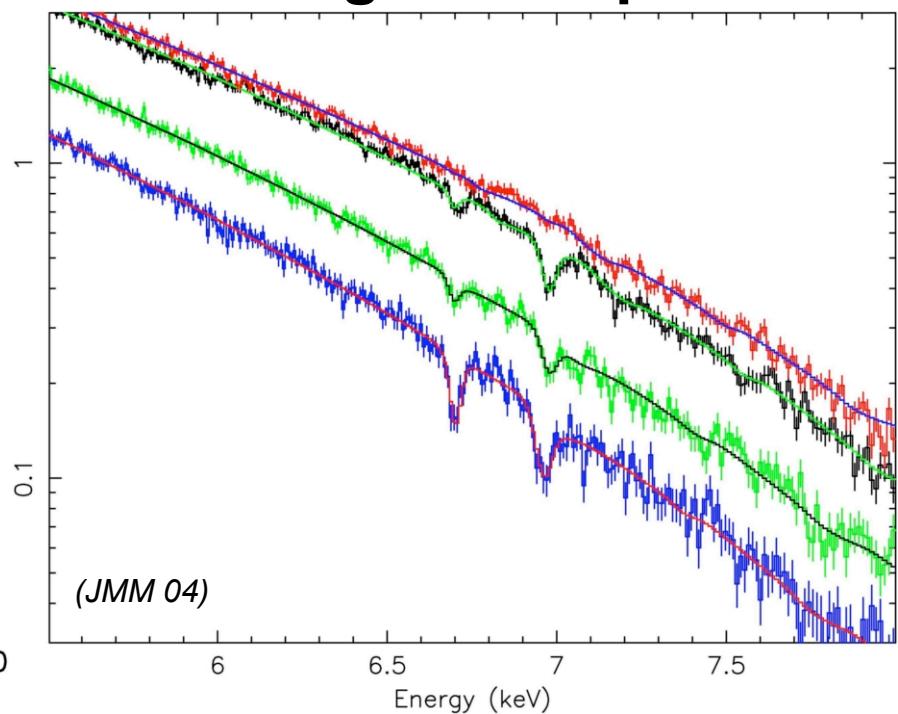
**GX 339-4, 75 ksec**

**3 E+37 erg/s at 8 kpc**



**H 1743-322, 50 ksec**

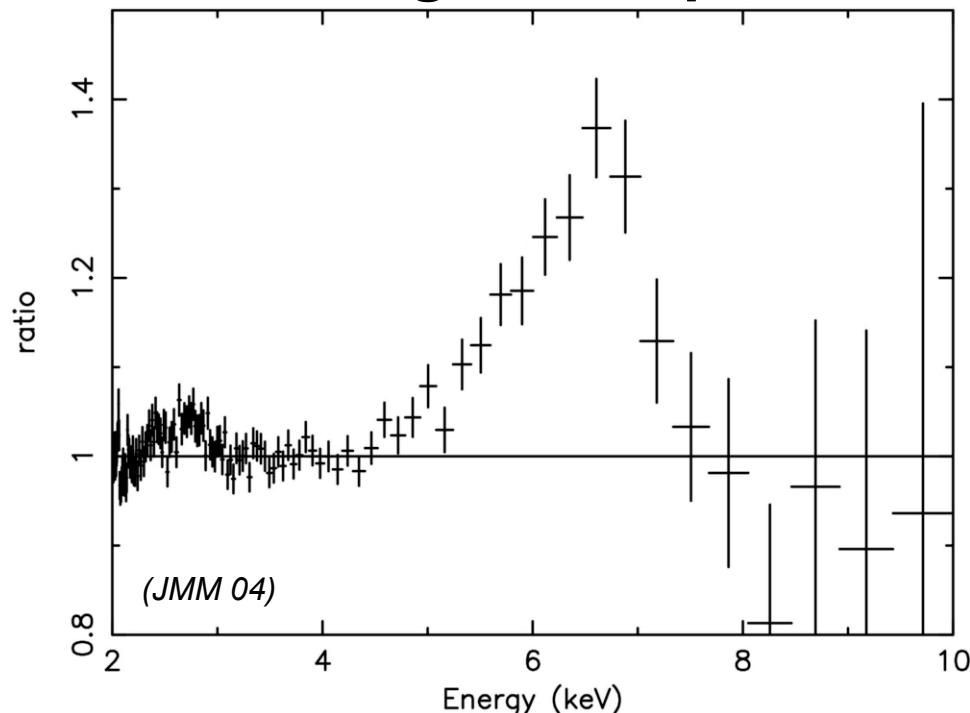
**3 E+38 erg/s at 8 kpc**



# ConXEUS Spectra

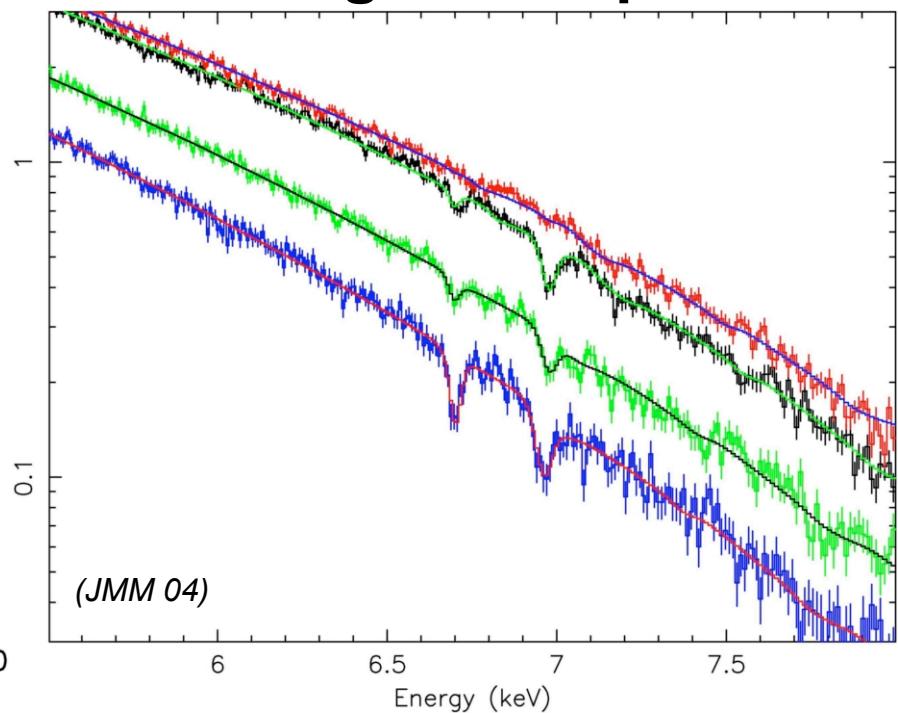
**GX 339-4, 75 sec**

**3 E+37 erg/s at 8 kpc**

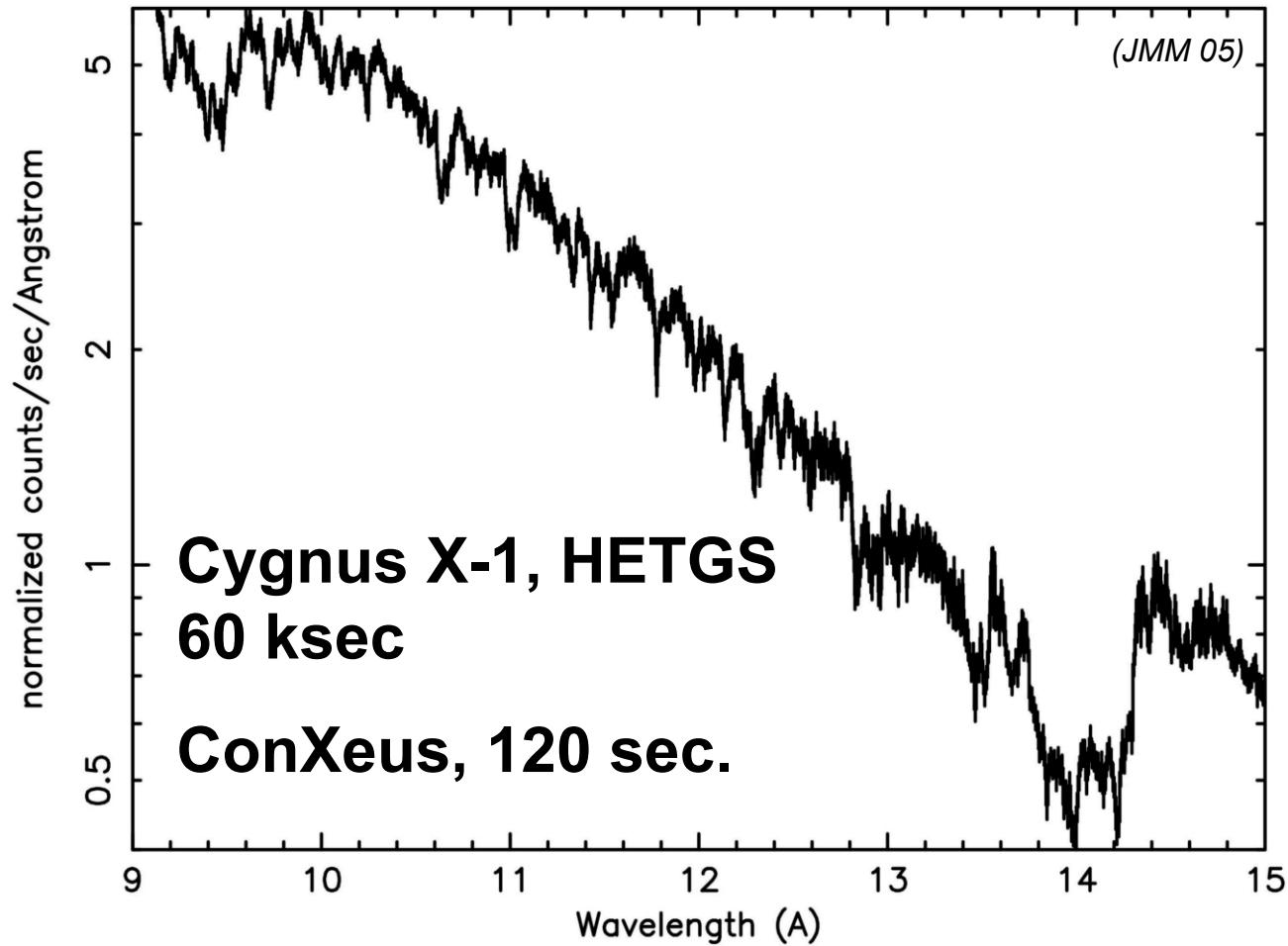


**H 1743-322, 50 sec**

**3 E+38 erg/s at 8 kpc**



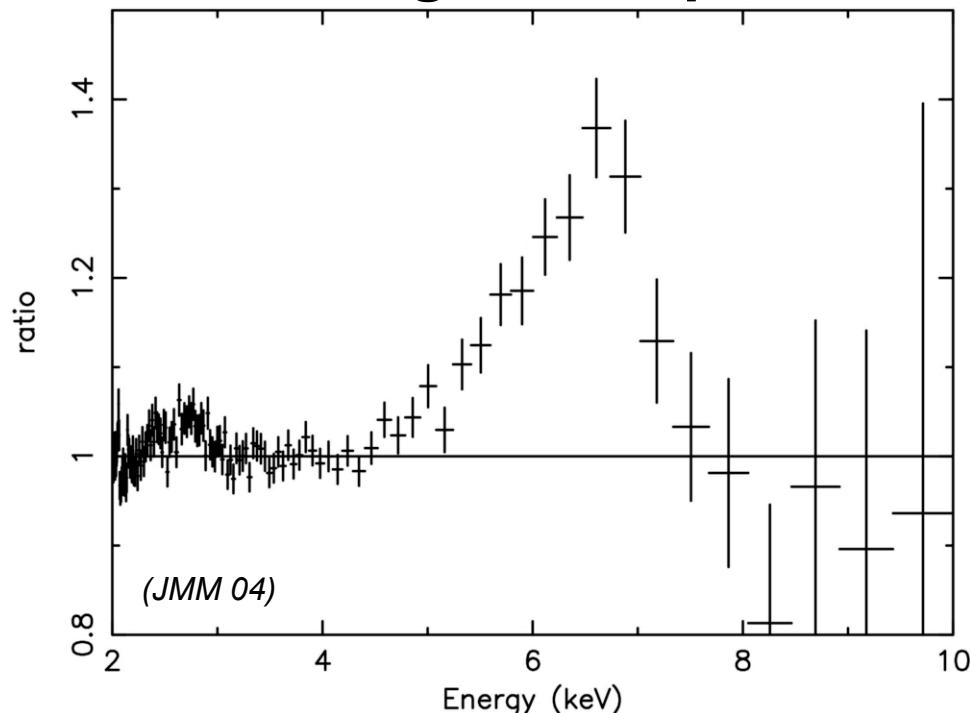
# On dippers, high inclination sources, hi-res spectra



# ConXEUS Low L<sub>X</sub> Spectra

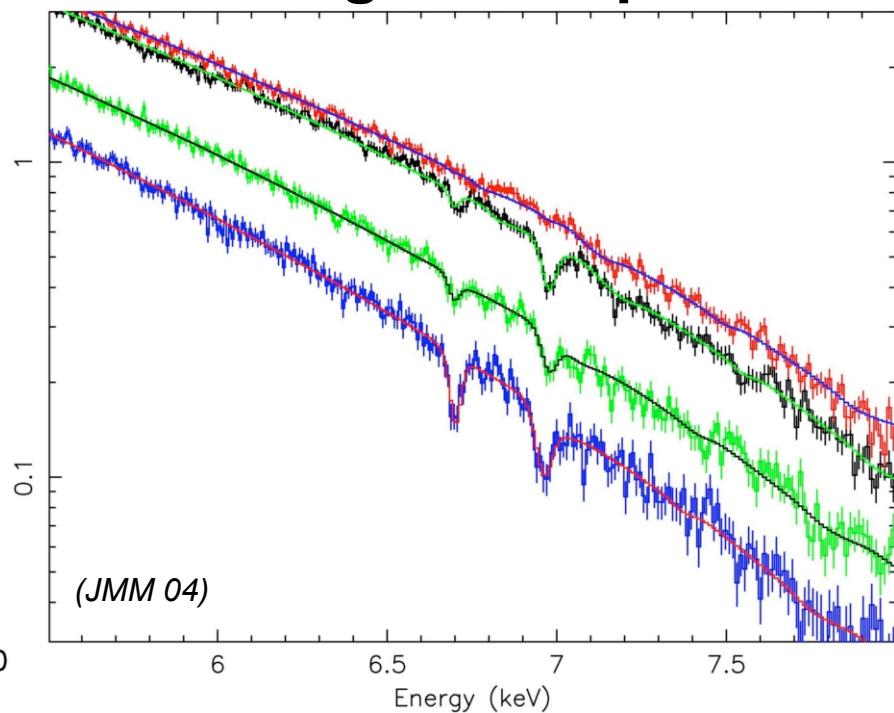
**GX 339-4, 75 ksec**

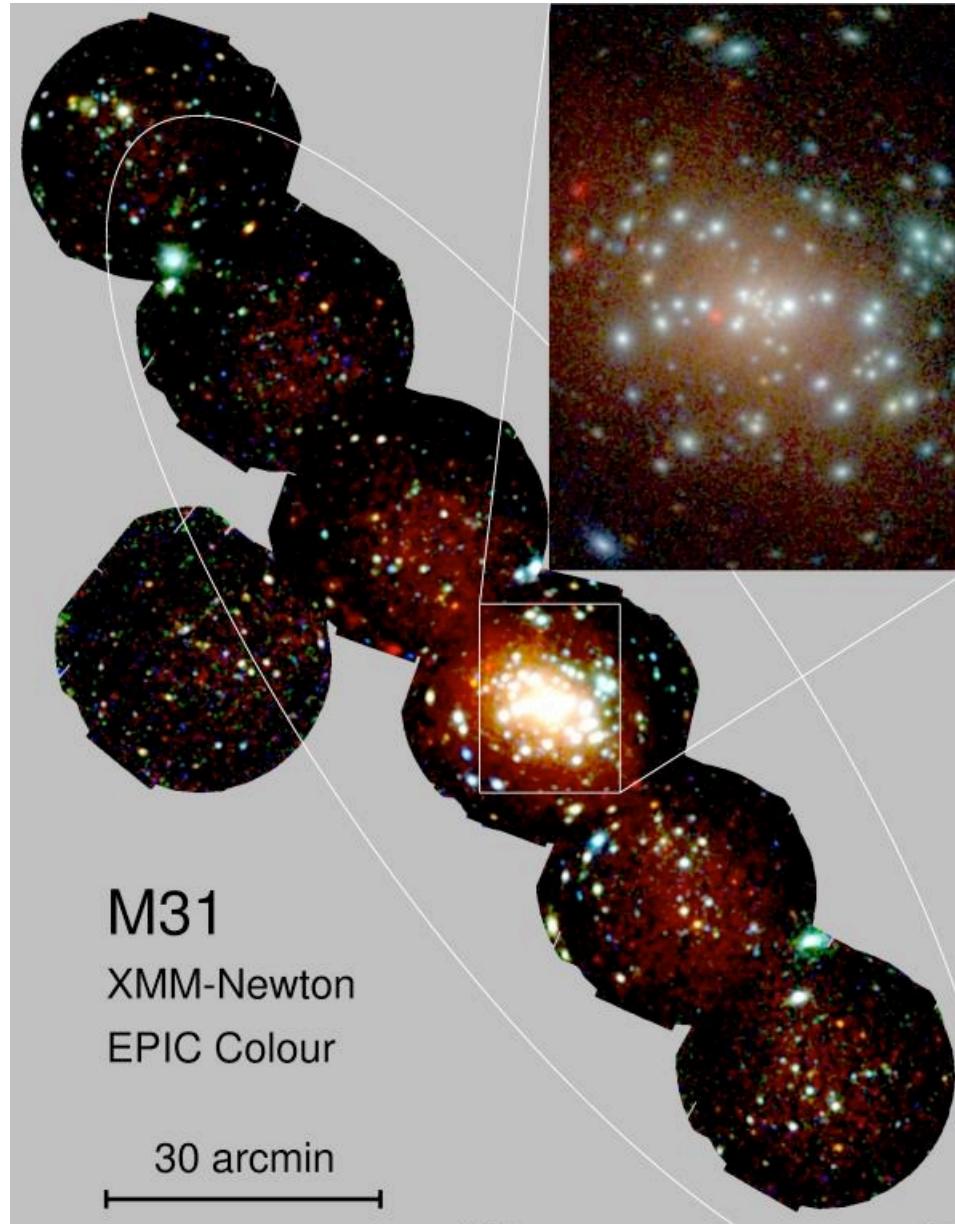
**3 E+34 erg/s at 8 kpc**

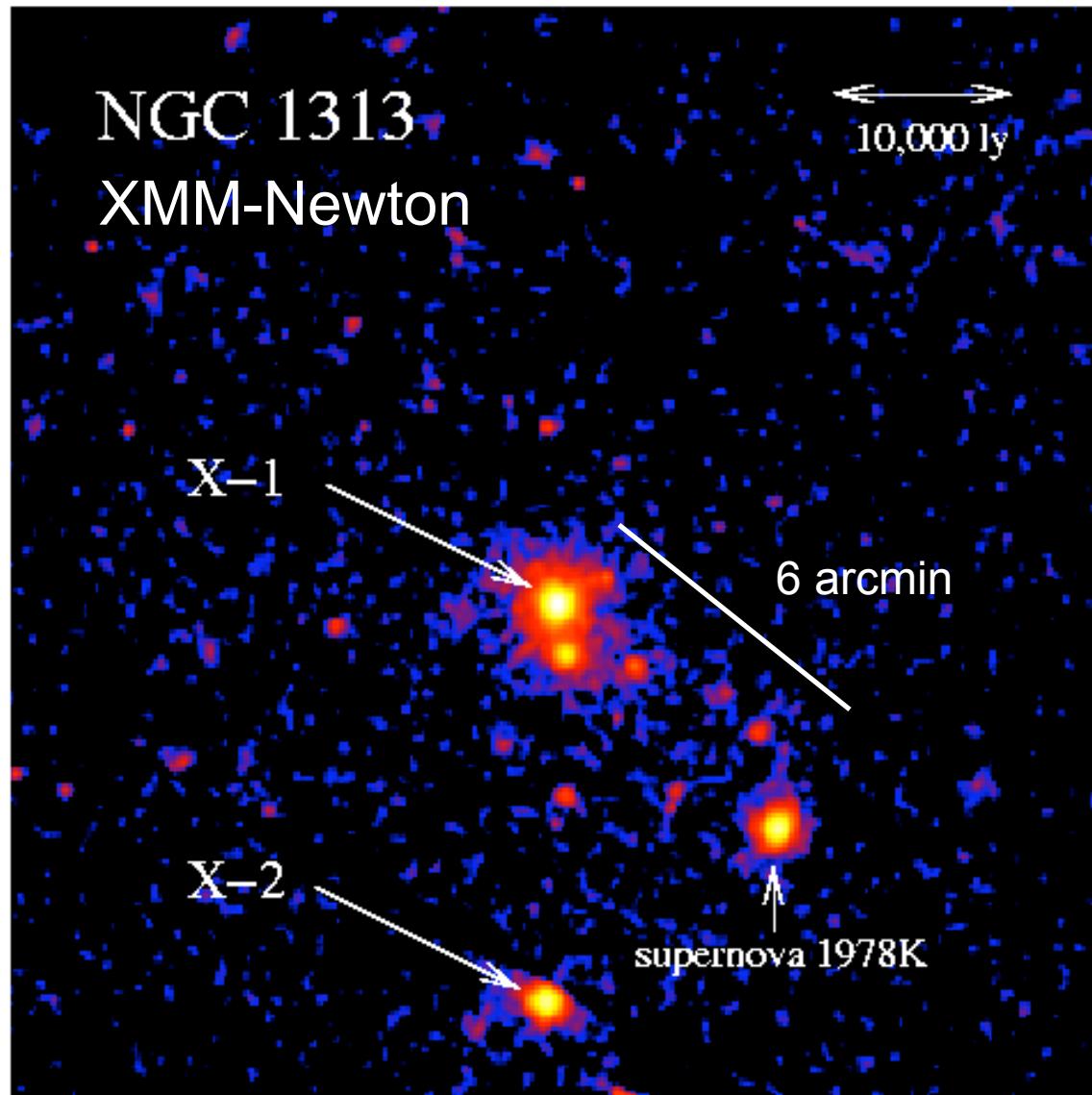


**H 1743-322, 50 ksec**

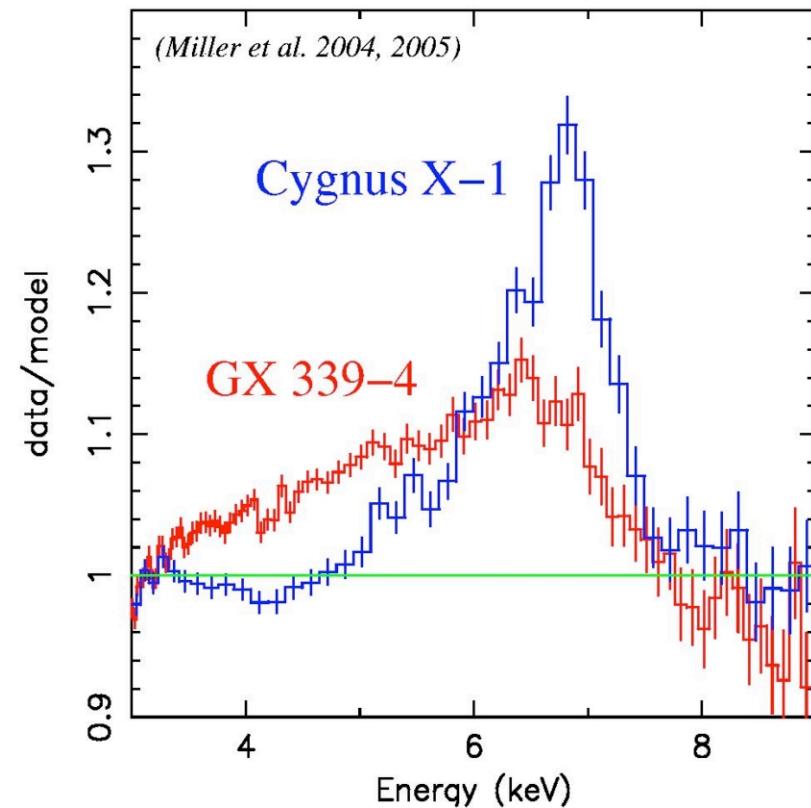
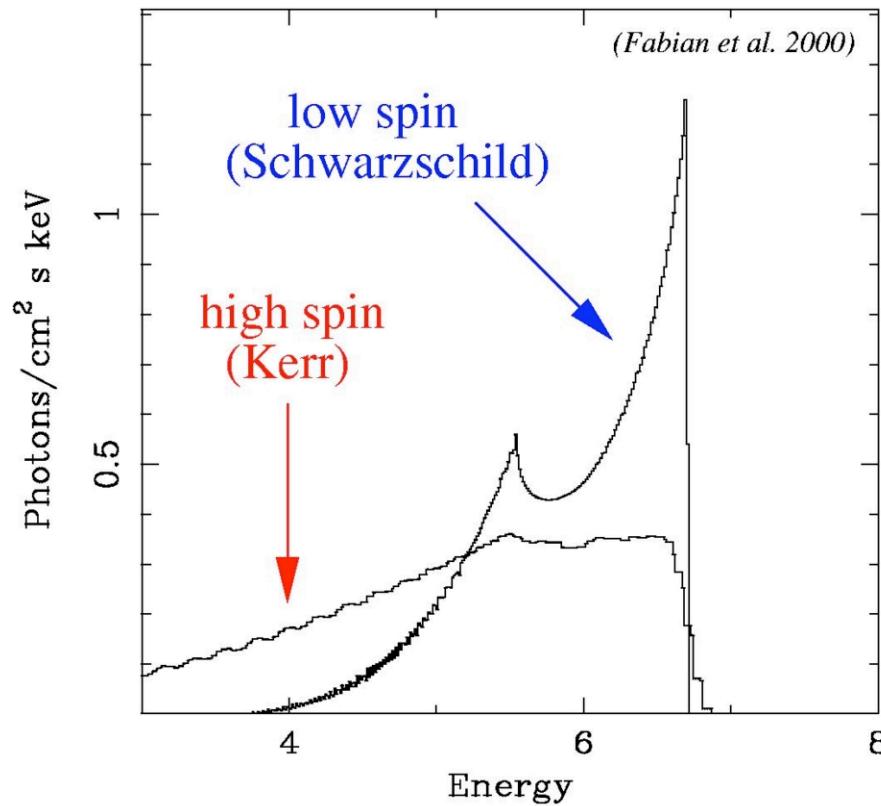
**3 E+35 erg/s at 8 kpc**







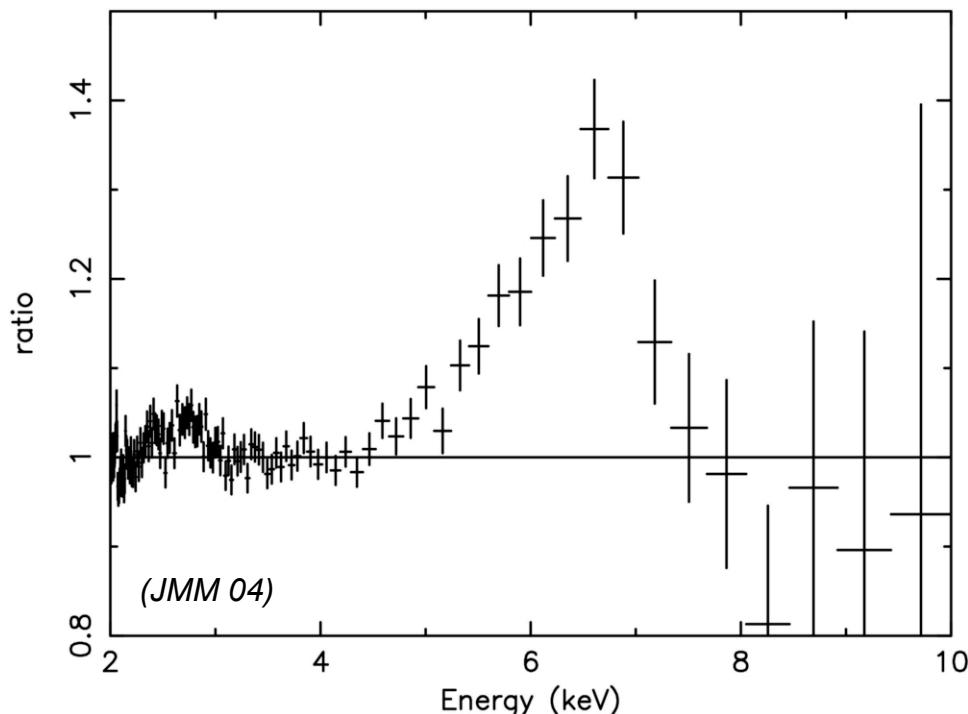
# Stellar-mass black hole spin



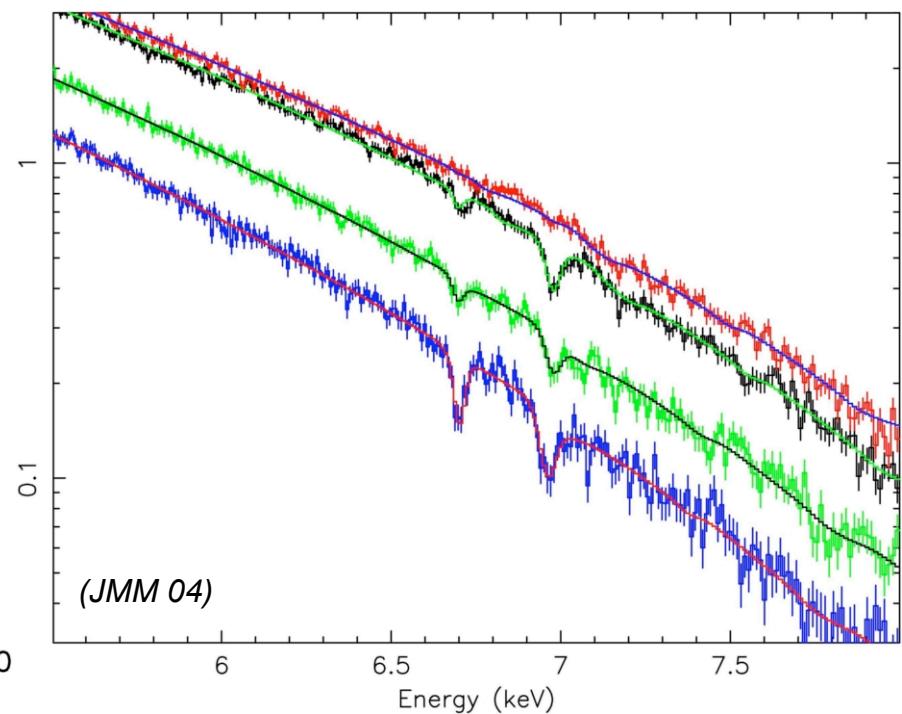
ConXEUS will allow us to investigate the origins of spin by making feasible a census of spin parameters in the Local Group and nearby galaxies.

# $\sim$ 500 ksec ConX-EUS M31 Spectra

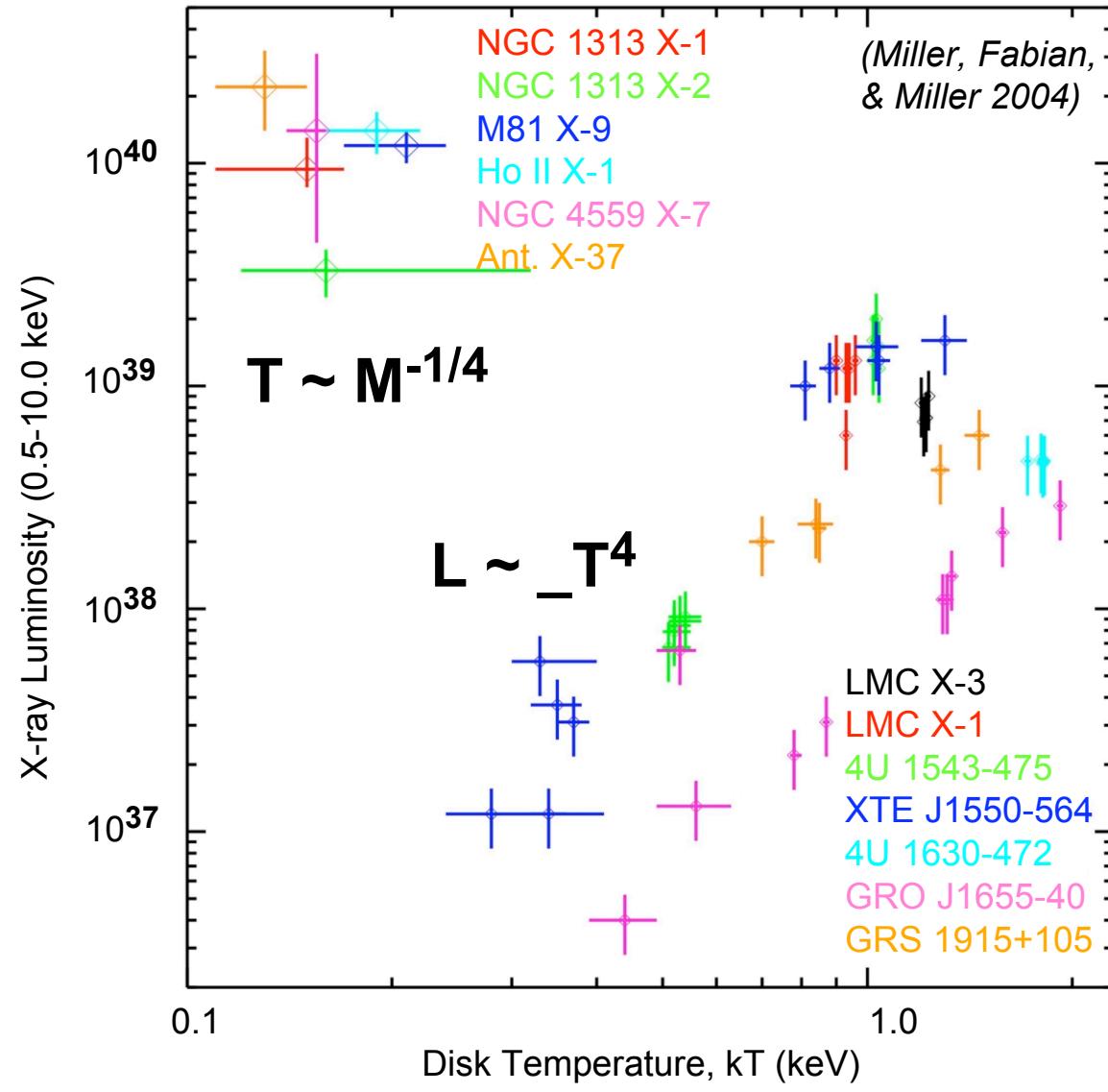
M31 XRB @  $3 \times 10^{37}$  erg/s



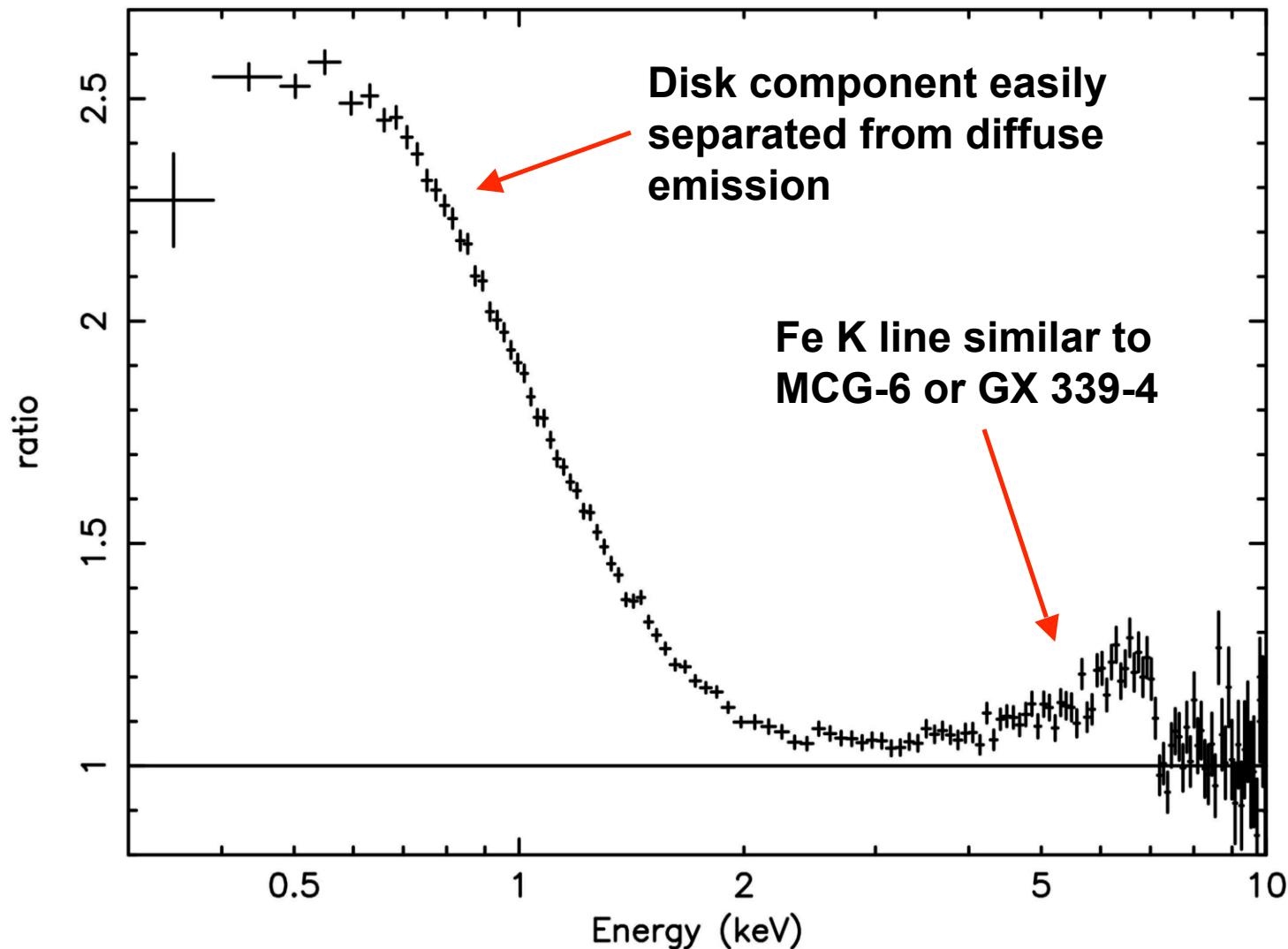
M31 XRB @  $3 \times 10^{38}$  erg/s



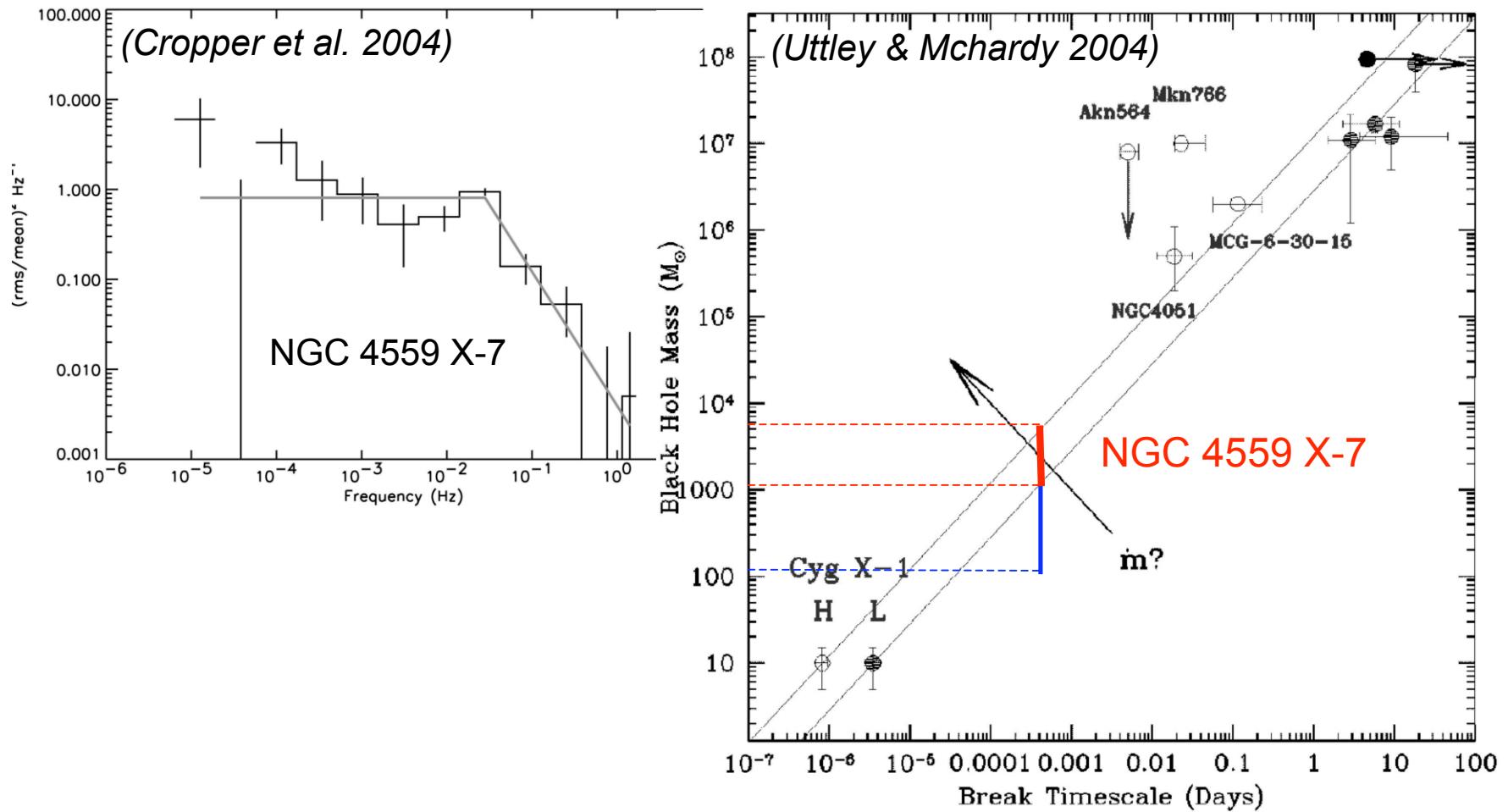
# IMBHs may be hiding in plain sight in ULXs



# 30 ksec on NGC 1313 X-1 with ConX-EUS



# Timing for binaries in nearby galaxies



**100 ksec stare at  
GBH to do GR**

**1 Crab flux w/  
high livetime**

**100 ksec on GBH to  
study low LX/L<sub>Edd</sub>**

**Hours-timescale  
response**

**1 Msec stare at M31**

**60+ keV threshold**

**300 ksec, NGC 1313  
IMBH spectra/timing**

**XMM-like spatial  
resolution**

**10+ arcmin FOV**

# Summary

- With a bright source capacity, we can do remarkable GR studies of Galactic BHs. Strong tests of strong gravity.
- With XMM spatial resolution & FOV, study binaries in the local group & ULXs ( $d < 3\text{Mpc}$ ) as we study Galactic XRBs now.
- Low m-dot flows will finally be revealed.

# extras below

# Getting Mass Estimates

- Disk component:  $> 8\%$
- $L_X \sim 0.6-2.0 \times 10^{40} \text{ erg/s}$

- hard:soft  $\diamond 3:1$
- $kT = 230 \pm 20 \text{ eV}$
- $\chi^2 = 1.76 \pm 0.07$

- Mass Scaling:

$$T \sim M^{-1/4}$$

$kT \sim 1.0 \text{ keV}$  for  $10 \text{ Msun}$  BHs

$$\diamond M \sim 4000 \text{ Msun}$$

$$M = f^2 [K/\cos(i)]^{0.5} (d/10\text{kpc})/(8.85\text{km})$$

$$\diamond M \sim 400 \text{ Msun}$$

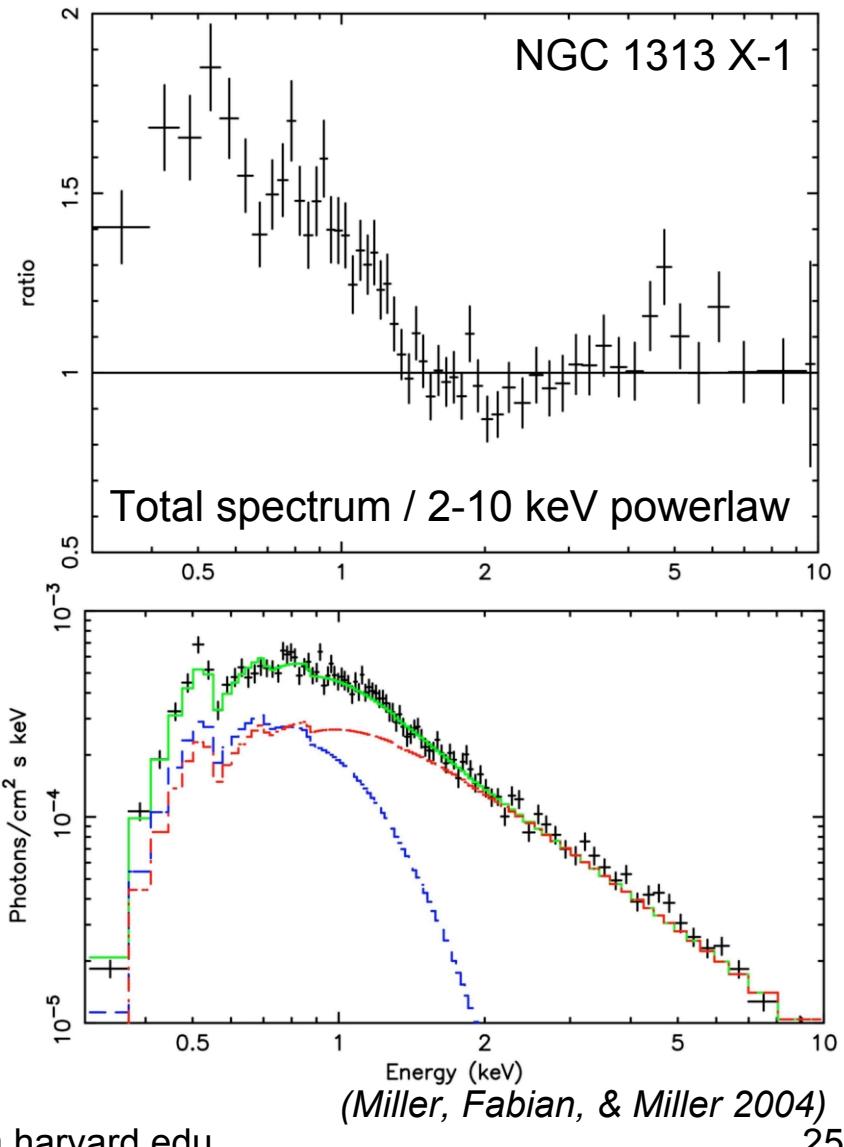
$$L_X / L_{\text{Edd}}$$

$$\diamond 110 \text{ Msun}$$

$\sim 1000 \text{ Msun}$  BH @  $L_X \sim 0.1 * L_{\text{Edd}}$  ?

3/16/05

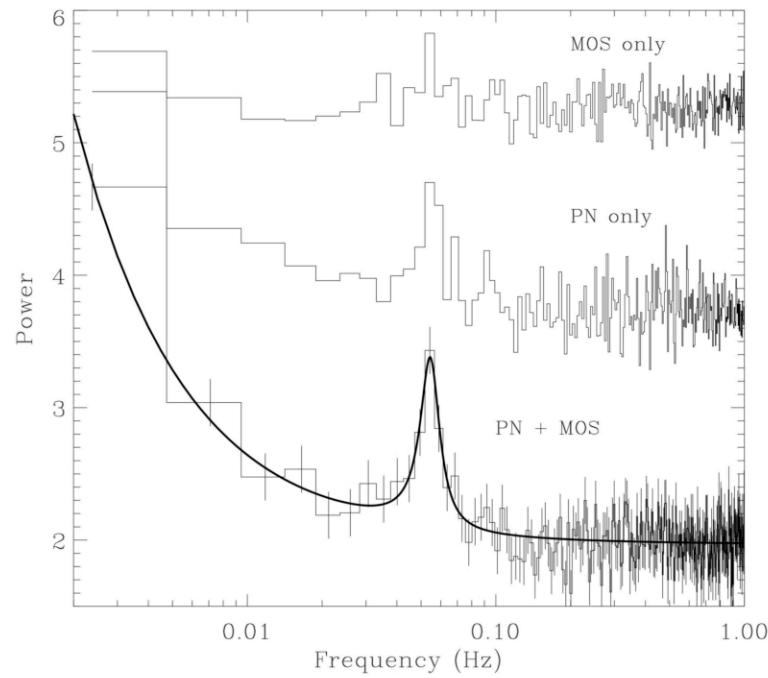
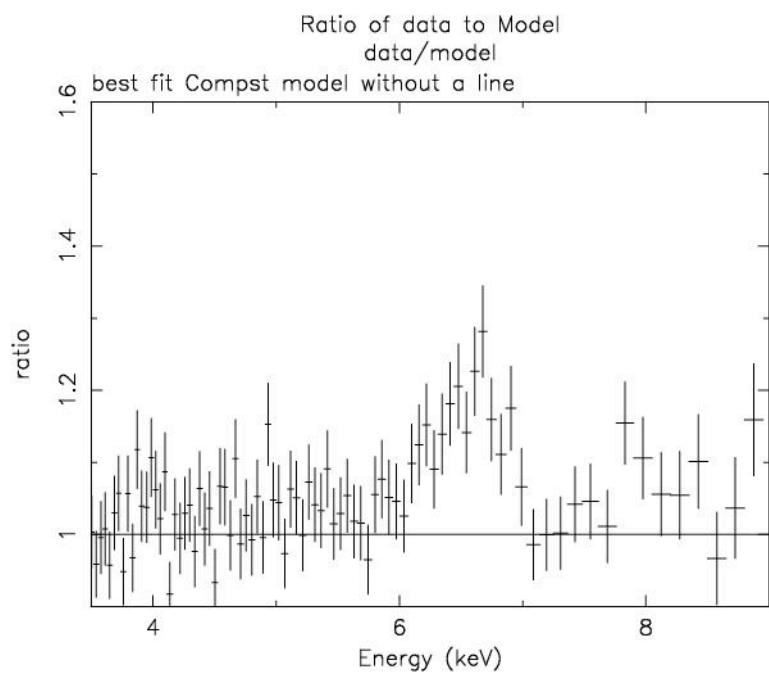
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# How to do better:

(Strohmayer & Mushotzky 2003)



9-Jan-2003 15:41

# The QPO Equation (see vdK95):

$$\bullet N_{\text{--}} = 0.5 * [s^2/(s+b)] * (\text{rms})^2 * \sqrt{T/\text{--}}$$

- ◊ For a QPO of a given  $q$ , S/N grows linearly with count rate (effective area) for  $b \ll s$ .
- ◊ With Con-X, then, QPO significances will be enhanced by  $R = A_{\text{conxeus}} / A_{\text{xmm}}$ .

# Relative Impact of ConXeus:

Local AGN in which reverberation  
mapping will work: 6-8

Galactic black holes in which  
GR effects can be probed over  
a 10 year mission: 10-15

ULXs with some hint of IMBH  
nature, on which Con-X can be  
decisive with XMM-like resolution: 20-30

# Relativistic lines in AGN, then and now. (see Nandra et al. 1997)

<u>ASCA lines “claimed”:</u>	<u>FWHM/ <math>\langle \text{FWHM} \rangle</math> &gt; 2</u>	<u>XMM/CXO rel. lines</u>
Mrk 335	<del>Mrk 335</del>	Mrk 335
Fairall 9	Fairall 9	<del>Fairall 9</del> - - -
3C 120	3C 120	3C 120 ???
NGC 3227	NGC 3227	<del>NGC 3227</del>
NGC 3516	NGC 3516	NGC 3516
NGC 3783	<del>NGC 3783</del>	NGC 4051
NGC 4051	<del>NGC 4051</del>	MCG-6-30-15
NGC 4151	<del>NGC 4151</del>	Mrk 766
Mrk 766	Mrk 766	<del>NGC 5548</del>
NGC 4593	<del>NGC 4593</del>	
MCG-6-30-15	MCG-6-30-15	IRAS 18325-5926
IC 4329A	<del>IC 4329A</del>	MCG-5-23-16
NGC 5548	NGC 5548	Q 0056-363
Mrk 841	<del>Mrk 841</del>	1H 0419-577
NGC 6814	<del>NGC 6814</del>	PG 1211+143
Mrk 509	<del>Mrk 509</del>	1H 0707-495
NGC 7469	<del>NGC 7469</del>	
MCG-2-58-22	<del>MCG-2-58-22</del>	